ASPETAR SPORTS MEDICINE JOURNAL

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Volume 6
Targeted Topic - Straight Science

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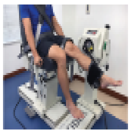

Figure 1

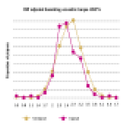

Figure 2

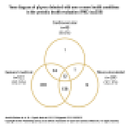

Figure 3

Table 1

THERE ARE MANY GOOD REASONS TO SCREEN YOUR ATHLETES

But predicting future injury is not one of them

– Written by Nicol van Dyk, Arnhild Bakken, Stephen Targett and Roald Bahr, Qatar

Mike is a physiotherapist working at a football club. Before the start of each season, the medical team does their planning for the year. An important part of this planning will be the periodic health evaluation (PHE), which is commonly referred to as the 'screening exam'. Like many football clubs worldwide, they complete a comprehensive pre-competition musculoskeletal screening consisting of a questionnaire, functional testing and isokinetic strength testing of the lower extremity[1]. There are multiple goals of these screening tests. In Mike's and many other physiotherapists' mind, one major goal is establishing which players are at risk of injury and providing potential interventions that could reduce the risk.

In occupational health and safety these kinds of screening tests are commonplace[2]. It is believed that identifying risk factors will allow for a suitable intervention to be put in place that might reduce the risk of injuries or better yet, prevent injuries altogether. There is, however, debatable evidence for the effect of these practices on general health and mortality rates. Nonetheless, interventions to promote safety and reduce the risk of injury/illness in the workplace are now routine.

Not long ago there were no restrictions on smoking in the workplace and ashtrays were a normal part of office equipment. Today, it is hard to imagine any institution that would still allow their employees to smoke inside the office. Another example might be providing protection against head injuries at a construction site. It is now mandatory that all workers (not just those doing high-risk activities) wear protective head gear and it would be unthinkable that any worker (or visitor) to a construction site would not be issued a hard hat.

In sports medicine, one of the goals of the PHE is to identify potential risk factors for injury and illness. It is important for sporting authorities to protect the health of the athlete, since professional sport is well-known for high risk of injury, illness, and the possible development of long-term health concerns. Organisations such as the International Olympic Committee (IOC) and FIFA have released guidelines on the PHE for athletes, attempting to set a standard for effective testing that would assist in early detection of cardiovascular and other potential health (medical) risks[4,5].

In fact, at Mike's club, they follow the FIFA guidelines and use the FIFA pre-competition medical assessment as a template for their PHE[5]. This consists of a comprehensive cardiovascular examination, general medical evaluation (including blood tests) and musculoskeletal assessment to be performed on all players.

The value of musculoskeletal testing and which are the best tests to be performed is often debated and consequently the exact makeup of the musculoskeletal assessment varies from club to club. Mike is particularly interested in isokinetic strength testing (Figure 1), which forms part of the testing battery for most teams since decreased strength has been shown to be a risk factor for hamstring injuries[6,7].

After the pre-season screening isokinetic strength assessment has been performed under his supervision, 10 of the players in Mike's squad are identified with a lower hamstring eccentric strength compared to the rest of the team, according to cut off points suggested in the literature as a high risk of injury[7]. Like many others, Mike is making the seemingly logical conclusion: These specific players have an increased risk of an injury if they continue playing and we need to target them with a specific strength training programme.

Would you agree? Now let's see how Mike has been tricked and why this statement is wrong.

IDENTIFYING RISK FACTORS WILL NOT IDENTIFY THE ATHLETES AT RISK

Hamstring injuries are common in sport and many studies have investigated the use of isokinetic testing to establish whether the strength of the quadriceps and hamstring muscles could be identified as risk factors for hamstring injury[7,8,9,10]. A recent meta-analysis identified age, previous injury and increased quadriceps strength as risk factors for hamstring injuries[11]. Although not supported by the meta-analysis, decreased eccentric hamstring strength has also been identified by several small prospective and retrospective studies as a risk factor for hamstring injury. However, Bahr and Holme have shown 200 injured subjects are needed to identify small to moderate associations with injury risk[12]. To overcome previous limitations of small sample sizes and low numbers of injuries van Dyk et al[13] recently performed a study which included 614 subjects and 190 injuries. They found significant association between decreased eccentric hamstring strength (when normalised to body mass) and increased risk of hamstring injury (odds ratio 1.37 per 1 Nm/kg difference in strength).

So case closed, right? It seems clear that there is an association between low hamstring eccentric strength and hamstring injury, that is until we look at the big picture, when it becomes evident we are being fooled by the group effect. To clarify, let's use smoking as an example.

A clear association between smoking and all-cause mortality, in particular lung cancer and cardiovascular disease, has been well established for more than 20 years[14]. The burden of this health risk on the health system was clearly substantial, therefore it did not take long (although many will argue much too long) to recommend a simple intervention strategy – quit smoking. This was supported by the evidence of a strong group effect. The group with a history of smoking has a significantly increased risk of developing cancer and cardiovascular disease compared to non-smokers. The message is clear – those who smoke are at higher risk than those who don't. A common mistake is to assume that what is true for the group is also true for the individual – it is not. You might never smoke in your life but develop any one of these conditions or you might smoke 20 cigarettes a day and never develop lung or cardiovascular disease. Why is this? Because identifying a group effect, even one as strong as this, does not tell us anything about individual risk.

This is how the evidence has tricked Mike as well. In Figure 2, the distribution of eccentric hamstring strength in the injured (red) and uninjured players (gold) are shown. Firstly, it is clear that the data from the injured players and the uninjured players overlap each other and that it would be impossible to accurately differentiate one group from the other using these measurements. Secondly, Mike knows that this level of difference may actually be due to the inherent variability in the hamstring eccentric strength measurements and not due to any true difference between individuals. A minimal detectable change (MDC) usually indicates how much a test score needs to change to know whether it represents a real and meaningful difference. The absolute difference in strength between the injured and uninjured group was only 7.2 Nm[13]. For this isokinetic strength test, the MDC was 73.7 Nm. That is ten times more than the absolute difference reported and clinically does not help to distinguish which players will get injured.

So an isokinetic hamstrings strength test is not sensitive or specific enough that we can establish a clear cut off line that would indicate which players in Mike's team are safe from injury and which players should improve their eccentric hamstring strength to hopefully reduce the risk of injury.

Receiver operating characteristics curve analyses are often used in tests such as these to determine the sensitivity (true positives: if the test identifies you will get a hamstring injury and you do) and specificity (true negatives: if the test says you are safe and will not get injury and you don't). In this example, receiver operating characteristics curve analyses revealed an area under the curve of 0.56. A value of 1.0 indicates perfect prediction and 0.5 indicates a useless test (one no better at identifying true positives than flipping a coin). So in this case is seems as though you might as well flip a coin rather than look at eccentric hamstring strength to predict who will get injured.

Could the odds ratio (OR) instead be useful to Mike? An OR is a statistical measure to quantify how strongly a factor, (in this case isokinetic strength) is associated with a particular outcome, (sustaining a hamstring injury). A recent infographic in the *British Journal of Sports Medicine* explains how to calculate the likelihood ratio of sustaining an injury from the odds[15]. With this study by van Dyk et al, an OR of 1.37 was reported. This implies that players with decreased eccentric hamstring strength have a 37% greater chance of hamstring injury. That seems like a rather large increase in risk. But what if we consider the base rate? The base rate represents the chance of a hamstring injury for anyone in the squad, regardless of any other factors. In football, it is reported as 1 in every 9 players – so the chance of a hamstring injury is about 11%. If we use the OR of 1.37 seen in this study and calculate the risk on top of the base rate with the likelihood ratio of 37%, it increases the chance to 14%. So using the OR helps Mike to understand that the players with decreased hamstring strength have a predicted injury risk of 14% compared with 11% for the whole squad.

What about other risk factors which reports much larger odds ratios? Another high-profile risk factor finding has been knee abduction in the drop jump test for anterior cruciate ligament (ACL) injury. Although incidence varies across different populations, it is commonly reported as 1 to

6%[16]. So let's assume a risk for ACL injury of about 6%. An OR of 2.3 is reported for lateral knee displacement (abduction) and ACL injury[17], which then changes the risk for the player from 6% to 12.5%. This means that there is still an 87.5% chance that the players 'at risk' of ACL injury will not sustain one.

Such differences are too small to make any strong recommendations regarding individual players based purely on the results of such tests and needs to be interpreted for each player on an individual basis.

A statistically significant association between the injured group and a specific risk factor clearly indicates that there may be a causal relationship between a specific test result and injury risk. These findings are important to improve and grow our understanding of how and why these injuries develop, but it still does not help Mike. This is not sufficient to use the test to predict who is at risk and who is not, or to identify the individual player who will go on to have an injury this season[18]. Not at all.

THEN WHAT ARE THE REASONS FOR SCREENING, IF WE CAN'T INDENTIFY THE PLAYERS WHO WILL GET INJURED?

There are numerous good reasons why Mike would want to continue screening his athletes. As outlined in the IOC consensus statement on PHE of elite athletes, it provides an opportunity to detect current musculoskeletal symptoms/issues which may influence the athlete's ability to train and compete[4]. A recent study of PHE examinations at Aspetar examined the findings of targeted musculoskeletal examination based on careful history. In the 558 professional football players included more than a third had a musculoskeletal condition requiring follow-up in the form of prevention intervention or treatment. (Figure 3)[19].

Detecting current musculoskeletal conditions

In Mike's squad of 30 players, he would have identified at least 10 players who might require some form of intervention or treatment. This might be as simple as reassuring a player regarding an ongoing injury or physical symptoms or the introduction of a treatment programme that is targeting the whole team.

Establish performance baseline and healthy state

Another good reason to conduct PHE is to establish a performance baseline for the athlete in the healthy state. For example, if one of Mike's players sustains an ACL or hamstring injury during the season, the isokinetic strength test or functional tests performed during screening represents an accurate reference point for the clinician to determine rehabilitation response/success and can assist in return to play decision-making. Alternatively, if the club decides to add a specific training/strengthening programme during the season, a baseline reference point might assist the team to establish whether or not such a programme has been successful.

Building the clinician-athlete relationship

Another potential benefit of conducting regular a PHE is establishing or building a relationship between the athlete and the health personnel, which can positively influence the care of the player. It is also an opportunity to provide education regarding certain policies or injury prevention strategies and to receive both subjective and objective feedback from the players on their current health status. Furthermore, a review of medications and supplements can be undertaken to avoid inadvertent doping[20]. In some settings, a PHE might be necessary to satisfy the medico-legal duties of care, for example a mandated medical assessment as part of a tournament.

CLINICAL IMPLICATIONS

Group effects are commonly misinterpreted as individual risk and incorrectly used to make injury prediction for individual athletes. It is important to understand that identifying isolated risk factors or even their interactions with other risk factors, does not enable you to predict which individuals will go on to have an injury.

We often want to simplify results when determining injury risk, but this is not the true picture. To illustrate the point in a different way, we present two ways in which Mike can think about when interpreting the test results:

Reasoning 1:

- *Decreased eccentric hamstring strength = risk factor for injury*
- *Johnny = Decreased eccentric hamstring strength*

therefore

- *Johnny will get injured*

OR

Reasoning 2:

- *Decreased eccentric hamstring strength = risk factor for injury (at group level)*
- *Johnny = Decreased eccentric hamstring strength (at individual level),*

therefore

- *Although Johnny has decreased eccentric hamstring strength that is associated with an increased risk of injury, he may not have an injury (and someone with normal hamstring strength may have an injury). But since Johnny is part of the group and the risk of the whole group is increased by having decreased eccentric hamstring strength, it is worthwhile improving the hamstring strength of the whole squad as some hamstring injuries will also occur in those with normal hamstring strength. Johnny might still have an injury, but we can improve his odds.*

It is not strange that Reasoning 1 is appealing, mainly because it is easy to follow and requires relatively little cognitive effort. The correct approach is, of course, shown in Reasoning 2. The difficulty comes in understanding the statistical process and what the results really mean. Mike now understands that identifying an isolated risk factor in a specific group cannot identify the individual players who will sustain an injury. So when reading results where statistical significance ORs, likelihood ratios and cut-off values are reported, it is also important to look for the distribution of the players in these studies, the effect size or even the absolute difference to understand the clinical value. Mike will not be tricked again - and neither should you.

We would not recommend that you suspend all musculoskeletal screening at the club since a PHE has other benefits (Table 1) such as allowing for the early detection of musculoskeletal issues, measurement of baseline values and building relationships between medical staff and players. If approached with these goals in mind the PHE or annual pre-season screening should remain a part of the pre-season preparations for every team.

Identifying risk factors is a vital step in the process of understanding how we can improve our injury prevention efforts. Although we cannot identify athletes on an individual basis, we can implement group interventions aimed at reducing the risk for an entire team or group of players. As injury prevention research continues to grow and mature, it moves us closer to protecting the health of our athletes and ensuring the safe participation in sport.

CONCLUSION

Risk factor identification is valuable in growing our understanding of specific injuries and which factors may be important for how they happen, but it does not allow for a simple, direct translation to injury prediction. However, PHE is a valuable tool that allows the clinician to monitor, engage and manage the musculoskeletal health of the athlete in a meaningful way.

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